BELL WORK
10-Feb-2015

1. Name two substances that are in the gas phase at room temperature

2. What is one thing that you know about gases?

3. What is one thing you would be curious to know about gases?

Agenda

Review Test Questions

Computer simulation

Objective

To explore how gases are affected by different variables using a computer simulation

Computer simulation

- Launch the simulation

  - URL: http://phet.colorado.edu/en/simulation/gas-properties

-OR-

  - Google: “gas law PhET simulation”

Before you receive your worksheet show me…

That you can…

1. Add both heavy and light gases to the container

2. Adjust the temperature of the container while holding the pressure constant

3. Decrease the volume of the container

BELL WORK 11-Jan-2015

<u>On a separate sheet of paper</u> draw three different balloons with air particles in them

1. One full of gas at room temperature
2. One full of gas at 0 degrees Celsius (~32 degrees Fahrenheit)
3. One full of gas at 50 degrees Celsius (~122 degrees Fahrenheit)

- **Using dots show where the particles are located inside each of the balloons**
- **Use arrows on the particles to indicate how fast they are moving (longer arrow = faster)**
- **rank the balloons from lowest to highest pressure**

Agenda

Notes – Gas properties and the KMT

Activity Stations – explaining every day events

Objective(s)

To identify the properties of gases

To explain properties of gases using the kinetic molecular theory

To explain real world phenomena using the kinetic molecular theory and the properties of gases

Demo

Write on your bellwork what you predict is going to happen

Write down what you actually observed

Properties of Gases

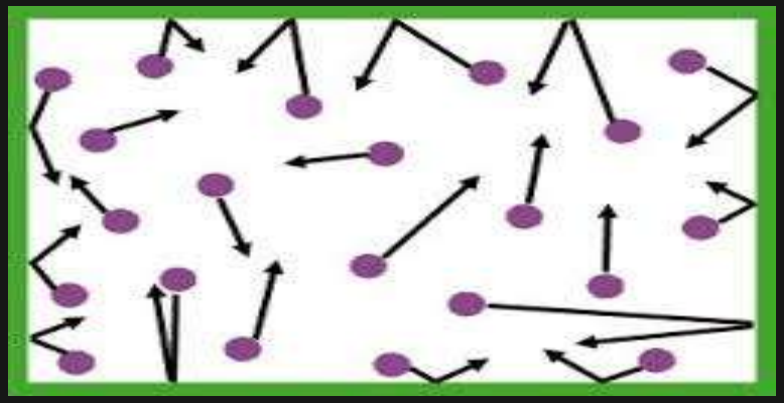
1. Gases assume the volume and shape of their containers.
2. **Gases are the most compressible state of matter.**
3. Gases will mix evenly and completely when confined to the same container.
4. **Gases have much lower densities than liquids and solids.**

Kinetic Molecular Theory (KMT)

Used to explain the behavior of gases

Kinetic Molecular Theory (KMT)

1. Gases are composed of particles moving in constant, random motion
2. Particles in a gas move in a straight line until colliding with another particle
3. The space between gas particles is much greater than that of solids or liquids

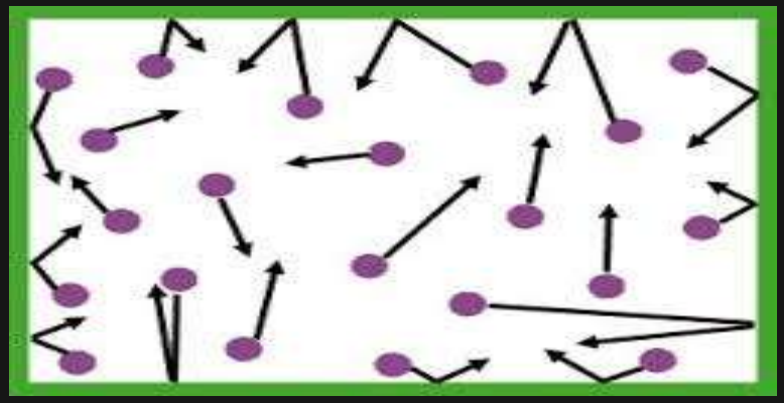


Kinetic Molecular Theory (KMT)

4. The attraction between gas particles is negligible

5. Energy is conserved when particles of a gas collide

6. The average kinetic energy of a collection of gas particles depends on the temperature of the gas



ACTIVITY!

- Two (2) sets of eight stations
- Two (2) people per station at a time
- One (1) prompt per station
- Three (3) minutes per prompt
- Individual answer sheets on a separate piece of paper

ACTIVITY!

For each situation explain:

1. **What gas properties are being observed (use your notes)**

2. **How do you explain these properties using the KMT (use your notes)**

3. **Give another example in which you observe the same situation**

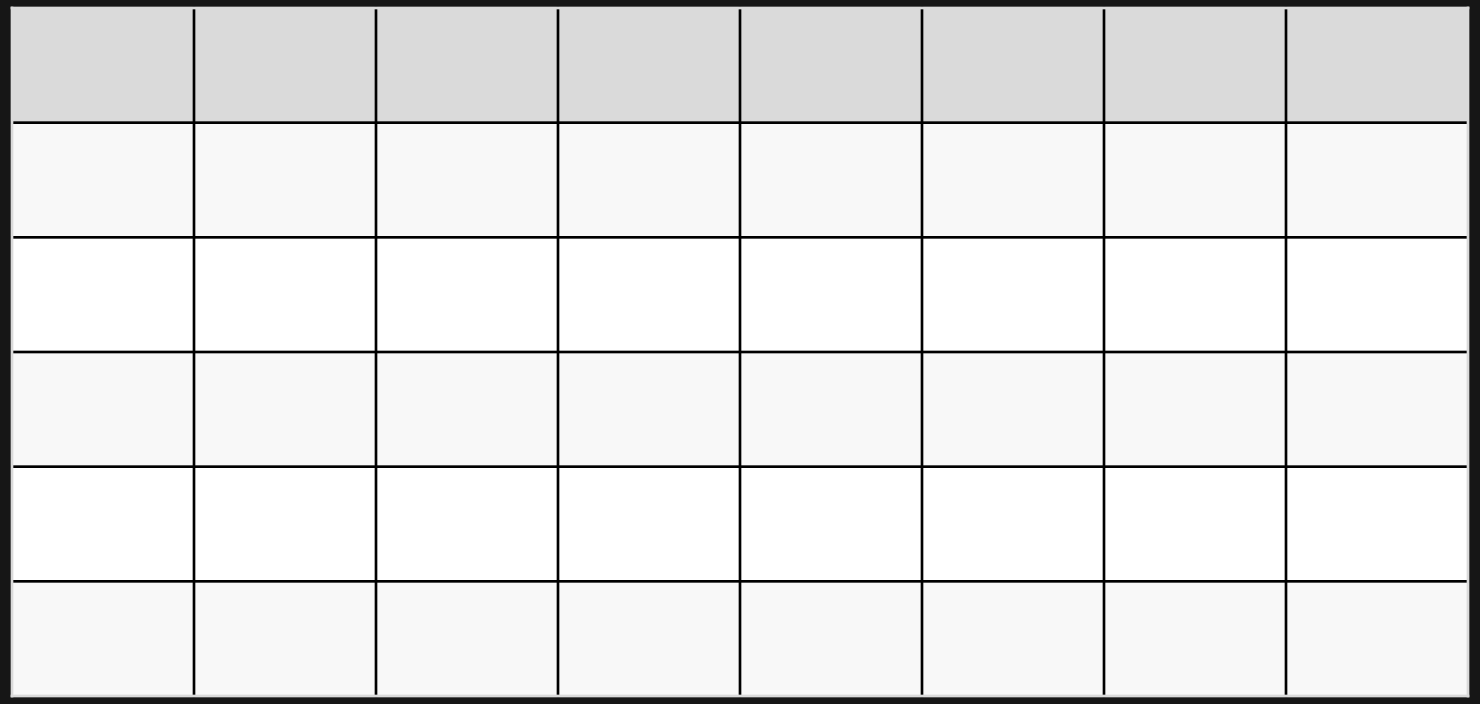
Exit Slip

1. **List the six postulates of the Kinetic Molecular Theory.**

2. **State which one you see at play most in your every day life and give an example of how you see it.**

Bellwork

On a piece of graph paper (that you can get from the front of the class) draw a 6X8 table like the one below



Agenda

Boyles Law Lab – you design the experiment!

Objective

To understand the relationship between pressure and volume mathematically and practically

What you will need…

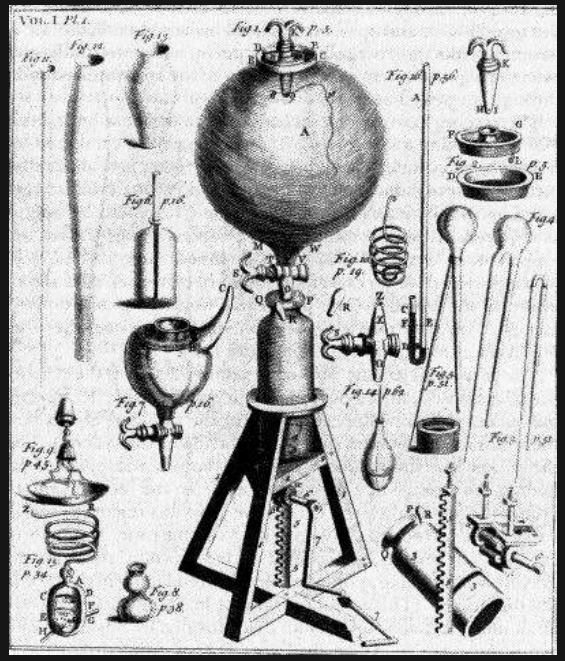
- The piece of paper with your table on it
- A blank sheet of paper to write your procedure and post lab on

Before you start collecting data

- Read over the lab with your lab group
- Devise a procedure for testing the relationship between the pressure and volume in a system
- Call me over and tell me your plan!

Boyle's Law Lab

Please do not damage the syringe



Bellwork
2/13/15

1. From the lab yesterday, what did you determine was the relationship between pressure and volume?

2. In your own words, and from your own experiences, define pressure.

3. Give two reasons why understanding the relationship between pressure and volume is important.

Agenda

Boyles Law Lab Discussion

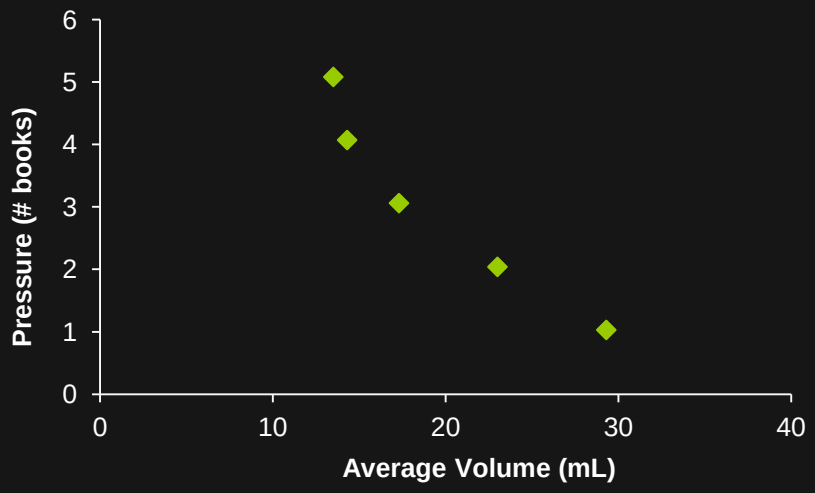
Notes on pressure

Objective

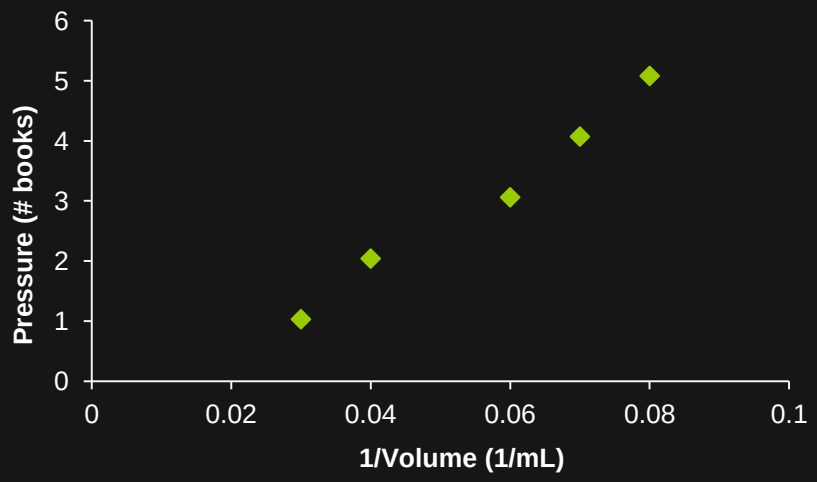
You will be able to use Boyle's Law to calculate pressure changes due to volume changes and vice versa

Boyle's Law Lab
Data Analysis

Volume v. Pressure



1/Volume v. Pressure



Boyle's Law

In a system in which the amount of gas in a system stays the same and the temperature remains constant:

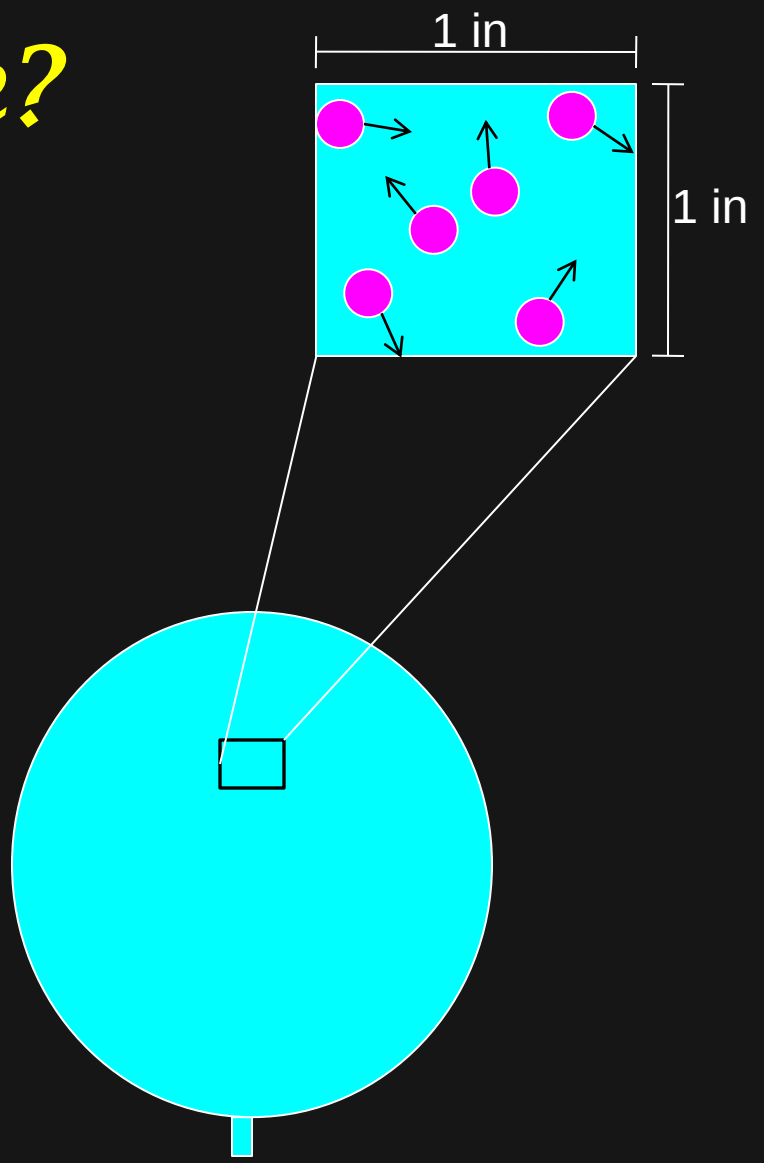
$$P_1V_1 = P_2V_2$$

P1 and P2 must be in the same units

V1 and V2 must be in the same units

What is pressure?

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$



Units of Pressure

1 pascal (Pa) =

1 N/m^2 =

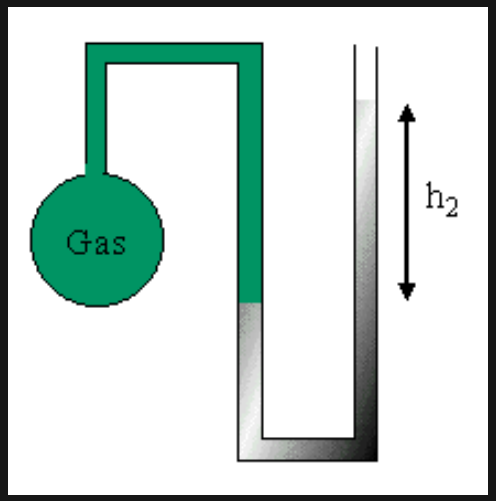
1atm =

760 mmHg =

760 torr =

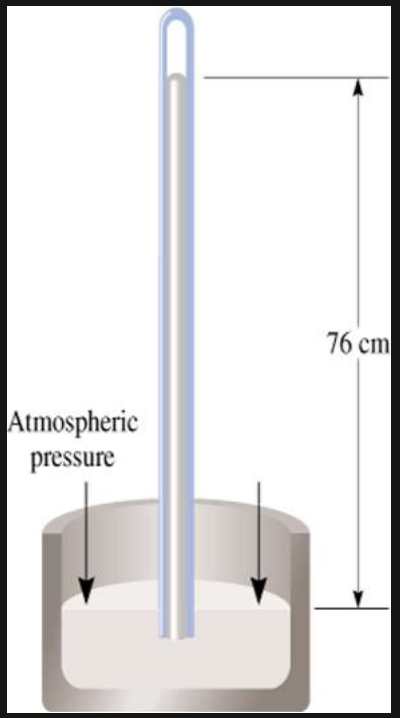
101.325 kPa

How do we measure pressure?



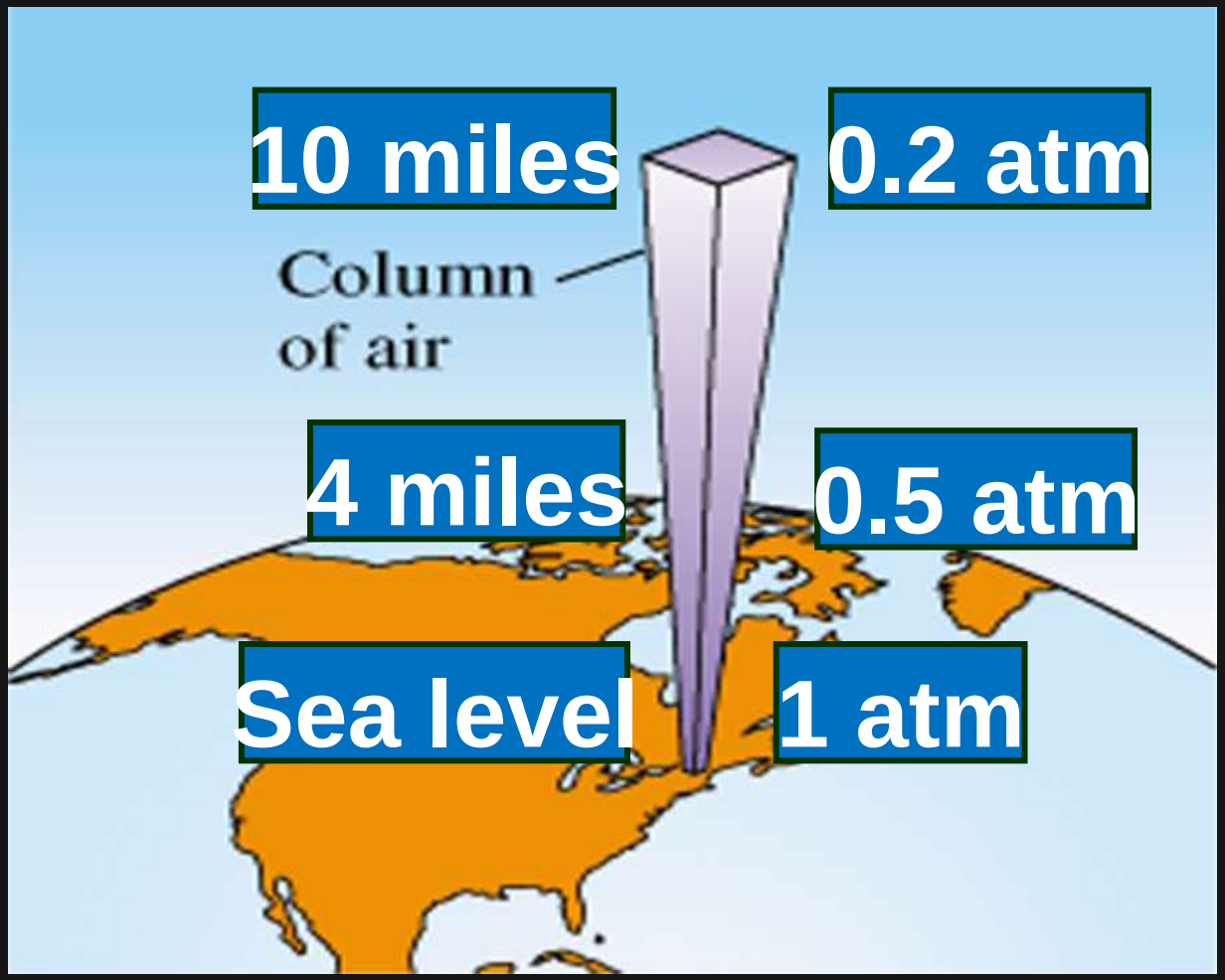
A manometer uses a U-shaped tube of liquid to measure pressure differences on either side of the liquid

A barometer uses the height of a column of mercury to measure gas pressure in mmHg



https://www.youtube.com/watch?v=EkDhlzA-lwI

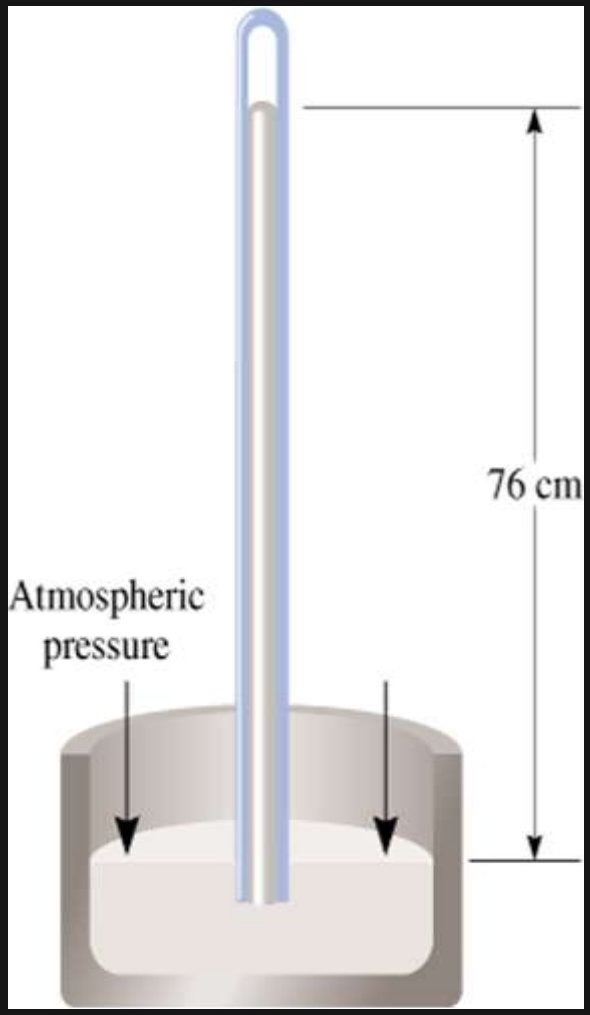
What is the pressure in mmHg at sea level?
What is the pressure in Pascals at sea level?



Try this…

Convert:

1. **727 mmHg into kPa**
2. **52.5 kPa into atm**
3. **0.729 atm into mmHg**
4. **522 torr into kPa**
5. **800.0 mmHg into atm**
6. **495Pa into mmHg**



Barometer

Standard Temperature and Pressure

Standard temperature and pressure **(STP)** refers to nominal conditions in the atmosphere at sea level. This value is important to physicists, chemists, engineers, pilots and navigators. Why?

Temperature = 0° C or 273K
Pressure = 1atm

Now Try This

At STP a sample of nitrogen takes up a volume of 50L. What is the new volume if the pressure is changed to 220 mmHg.

Elements that exist as gases at 25^0C and 1 atmosphere

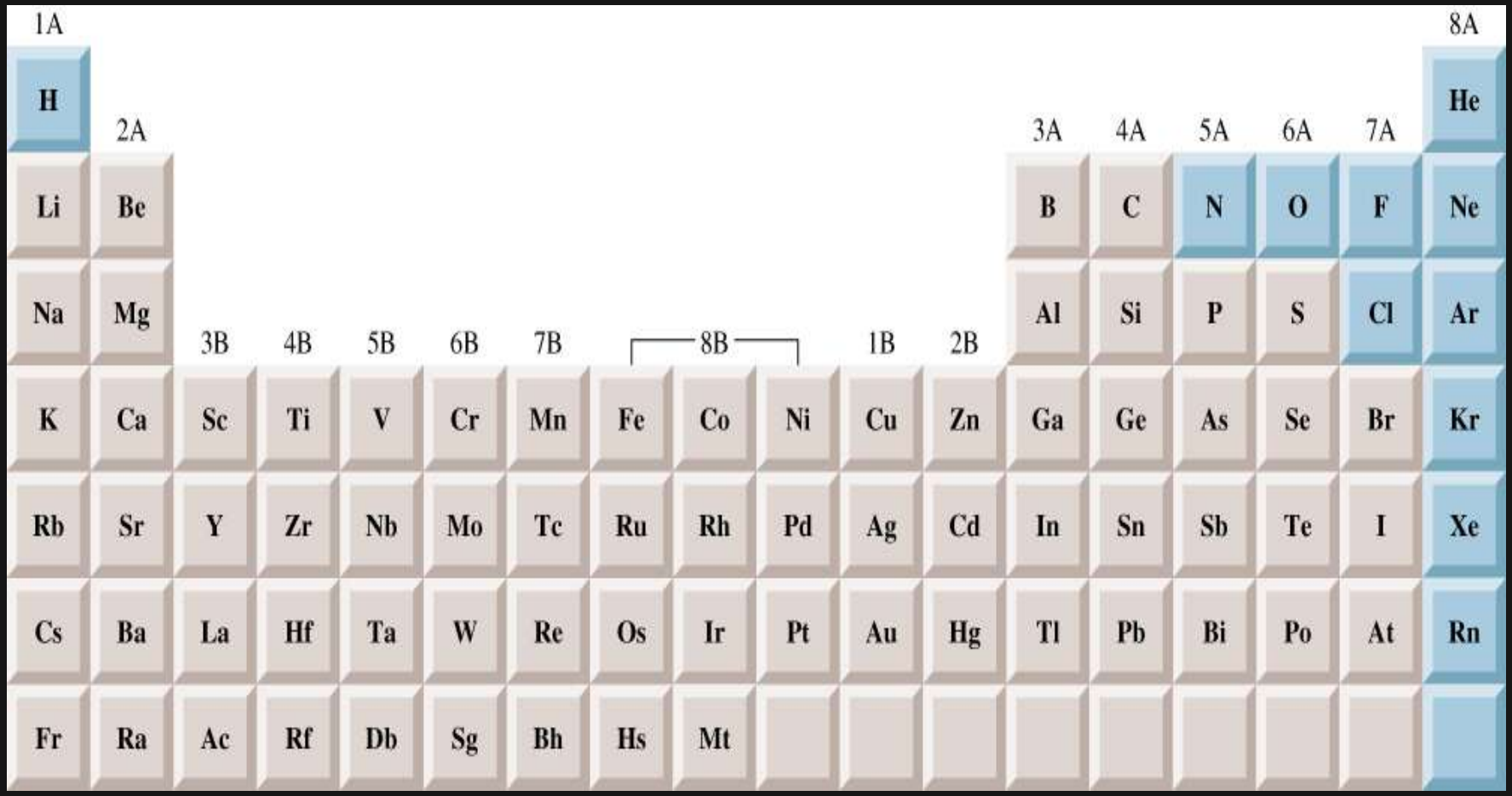


Table 5.1 Some Substances Found as Gases at 1 atm and 25°C

Elements	Compounds
H_2 (molecular hydrogen)	HF (hydrogen fluoride)
N_2 (molecular nitrogen)	HCl (hydrogen chloride)
O_2 (molecular oxygen)	HBr (hydrogen bromide)
O_3 (ozone)	HI (hydrogen iodide)
F_2 (molecular fluorine)	CO (carbon monoxide)
Cl_2 (molecular chlorine)	CO_2 (carbon dioxide)
He (helium)	NH_3 (ammonia)
Ne (neon)	NO (nitric oxide)
Ar (argon)	NO_2 (nitrogen dioxide)
Kr (krypton)	N_2O (nitrous oxide)
Xe (xenon)	SO_2 (sulfur dioxide)
Rn (radon)	H_2S (hydrogen sulfide)
	HCN (hydrogen cyanide)*

** The boiling point of HCN is 26°C, but it is close enough to qualify as a gas at ordinary atmospheric conditions.*

Bellwork 02/16/15

5L of H_2 gas is at a pressure of 877 mmHg:

1. What is the pressure of the gas in Pascals?
2. If the volume were increased to18L what would the new pressure be in atm?
3. How would the original pressure be different if the gas used was SF_6 instead of hydrogen? Why?

https://www.youtube.com/watch?v=1PJTq2xQiQ0

Agenda

1. HW questions
2. Collect HW and Post-lab
3. Test review?
4. Lantern Assembly

Before you start assembling your lantern..

As a lab group come up with a plan to put your lantern together. You have the following materials:

- Gores (the balloon)
- 20 gauge florist wire
- Candle with copper wire
- Tape
- Elmer's glue

Bellwork 02/17/15

1. Octane (gas) reacts with oxygen to form CO_2(g) and water vapor (see below). If 3,000 g of octane is burned how much CO2 is formed during the reaction?

1. Solve Boyle's law for P2
2. A sample of chlorine gas occupies a volume of 946mL at a pressure of 726mmHg. What is the pressure of the gas (in mmHg) if the volume is decreased to 154 mL?

Agenda

1. Launch lanterns
2. Boyle's Law Homework: how do we use the equation? How do we set up our problems?
3. Charles Law Lab and Discussion
4. Combined Gas Law?

All temperature must be converted to Kelvin

To convert $^0C \rightarrow K$

$T\ (K) = t\ (^0C) + 273$

To convert $K \rightarrow {}^0C$

$T\ (^0C) = t\ (K) - 273$

Why is the Kelvin scale used exclusively in gas law calculations?

Charle's Law Lab

(at least) Four data points:

1. **One at room temperature (record the temperature)**
2. **One using 600 mL of the ice water in the cooler (make sure not to grab any ice)**
3. **One using 300mL ice water and 300 mL tap water**
4. **On at least <u>ten degrees higher</u> than room temperature (*beginning warming water as soon as you get to your lab*)**

****Do more if you have time**

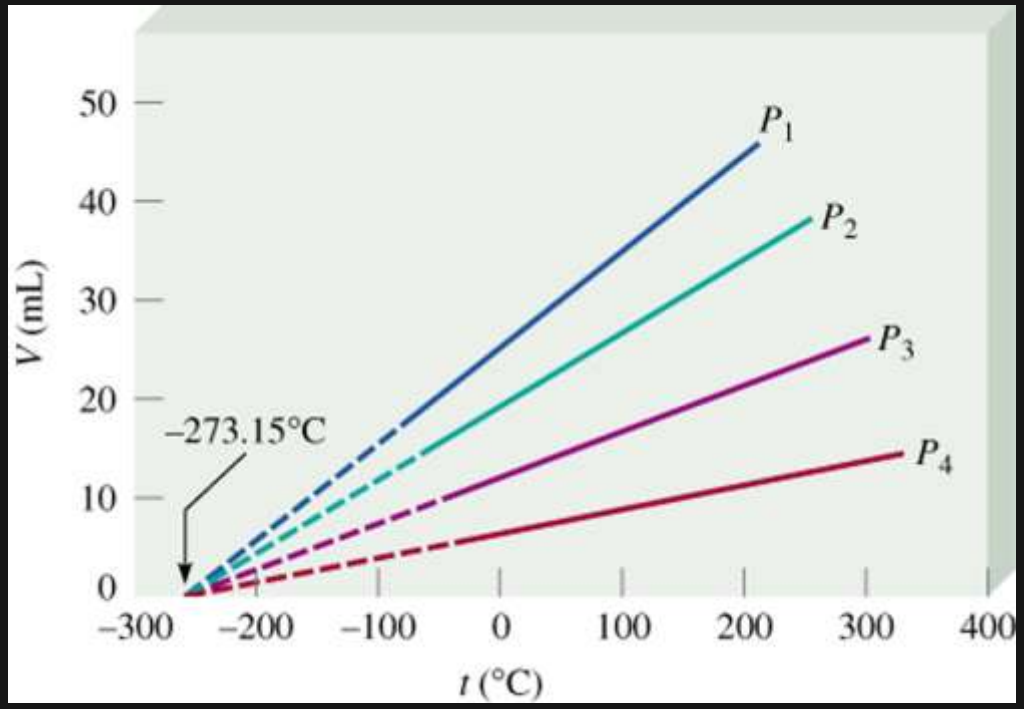
Bellwork
02/19/15

1. From the lab yesterday, what two variables were you measuring and how did you measure them?

2. What is the difference between Charles' Law and Boyle's Law? What must remain constant in order for both of these laws to hold true?

3. On a trip to the lake you attempt to blow up your beach ball in the morning when the temperature is at 15°C. Half way through you give up leaving the balloon containing a volume of only 3L. Later in the day you return to your ball when the temperature is at 30°C, what has happened to the volume of your beach ball? Do the calculation and describe what happened using the KMT and properties of gases.

Homework Questions?



Charles' Law

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\text{\% Error} = \left| \frac{\text{Theoretical Value} - \text{Experimental Value}}{\text{Theoretical Value}} \right| \times 100$$

Agenda

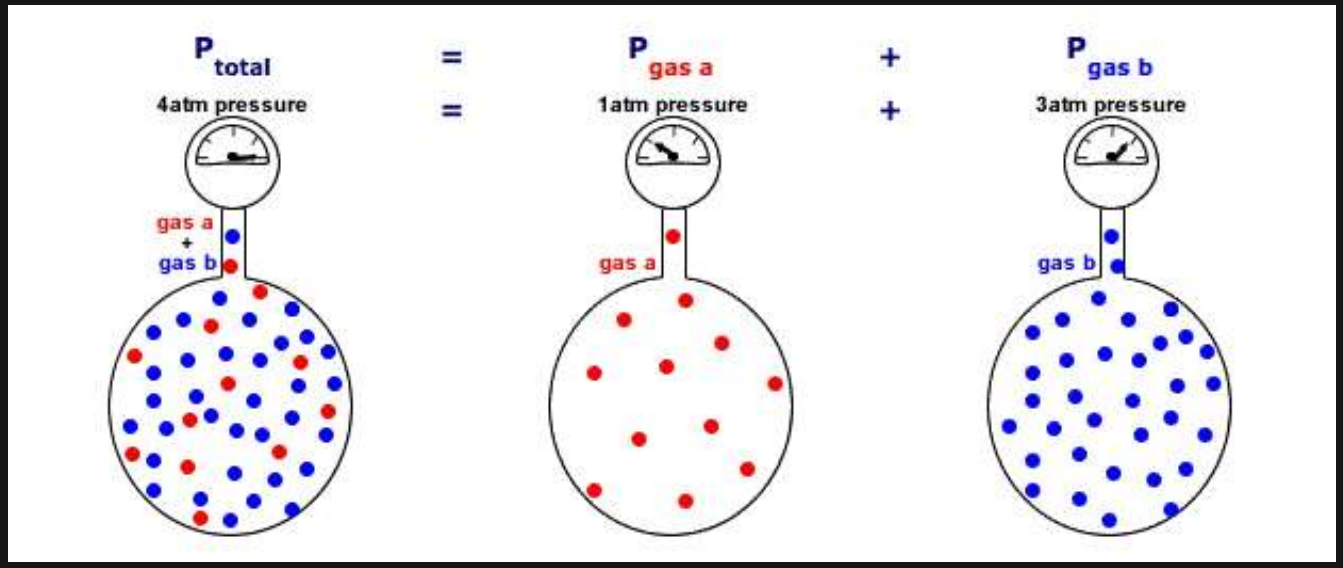
- Dalton's Law of Partial Pressures
- Combined Gas Law/Problem solving box
- Group problem solving and presentation

Objectives

- You will understand Dalton's Law of Partial Pressures and be able to apply it to calculations
- You will be able to determine which equation to use given a word problem.

Dalton's Law of Partial Pressures

At a constant volume and temperature the total pressure exerted by a <u>mixture</u> of gases is equal to the <u>sum</u> of their individual pressures



$$P_{total} = P_1 + P_2 + P_3 \ldots P_n$$

Try This

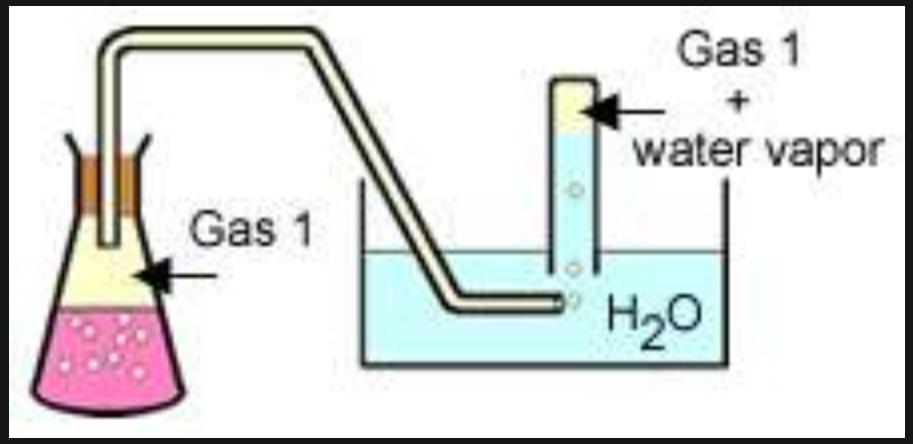
The air around us contains oxygen, nitrogen, carbon dioxide, and trace amounts of other gases. What is the partial pressure of oxygen at 101.3 kPa of pressure if P_{N2} = 79.1 kPa, P_{CO2} = 0.04 kPa, and P_{others} = 0.94 kPa?

Dalton's Law of Partial Pressures

When collecting a gas over water you need to account for the "Vapor pressure" of water at the collection temperature.

To find the pressure of the dry gas alone, we need to subtract out the pressure of the water vapor.

$$P_{dry\ gas} = P_{total} - P_{water\ vapor}$$



Dalton's Law of Partial Pressures

A sample of H_2 gas is collected over water at 14.0°C, vapor pressure of H_20 at 14°C is1.6kPa. The pressure of the resultant mixture is 113.0kPa. What is the pressure that is exerted by the dry H_2 alone?

$P_{dry\ gas}$ = ?
P_{total} = 113.0 kPa
$P_{water\ vapor}$ = 1.6 kPa

$P_{dry\ gas} = P_{total} - P_{water\ vapor}$

$P_{H2} = 113.0\ kPa - 1.6\ kPa$

Demo

What do we know so far?

With a constant amount of particles in a sample of gas…

Boyles law

$$P_1 \times V_1 = P_2 \times V_2$$

Gay-Lussac's Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Charles law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

How can we put it all together to determine relationships between all three?

Combined Gas Law!

When the number of gas particles in the system remains constant:

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

Rearrange the equation for:

1. **T1**
2. **P2**

Word Problem Solving Box

<table>
<tr><td colspan="2">1. What you want?</td></tr>
<tr><td rowspan="2">2. Given Information</td><td>4. Plan</td></tr>
<tr><td rowspan="2">5. Calculations for solutions</td></tr>
<tr><td>3. Useful formulas/ conversions</td></tr>
</table>

Word Problem Solving Box

Deep sea divers have to use a mixture of gases at depth in order to avoid sickness. If a tank contains 1.60atm of O_2, 0.5atm of He and 2.9atm of N_2, what is the total pressure of the tank?

1. What you want? **P_{total}**	
2. Given Information **P_{O2} = 1.6atm** **P_{He} = 0.5atm** **P_{N2} = 2.9atm**	4. Plan: **Use Daltons law to solve for P_{total}** 5. Calculations for solutions
3. Useful formulas/ conversions **$P_{total} = P_1 + P_2 + P_3$**	

Bellwork
02/19/15

1. Re-arrange the combined gas law for T2

1. What must all temperatures be converted to before solving gas law problems?

2. A sample of hydrogen gas is collected over water at 14.0 (P_{H2O} = 1.6 kPa). The pressure of the resultant mixture is 117.0 kPa. What is the pressure that is exerted by the dry hydrogen alone?

Agenda

- Avogadro's and Idea Gas Law
- Demo

Objectives

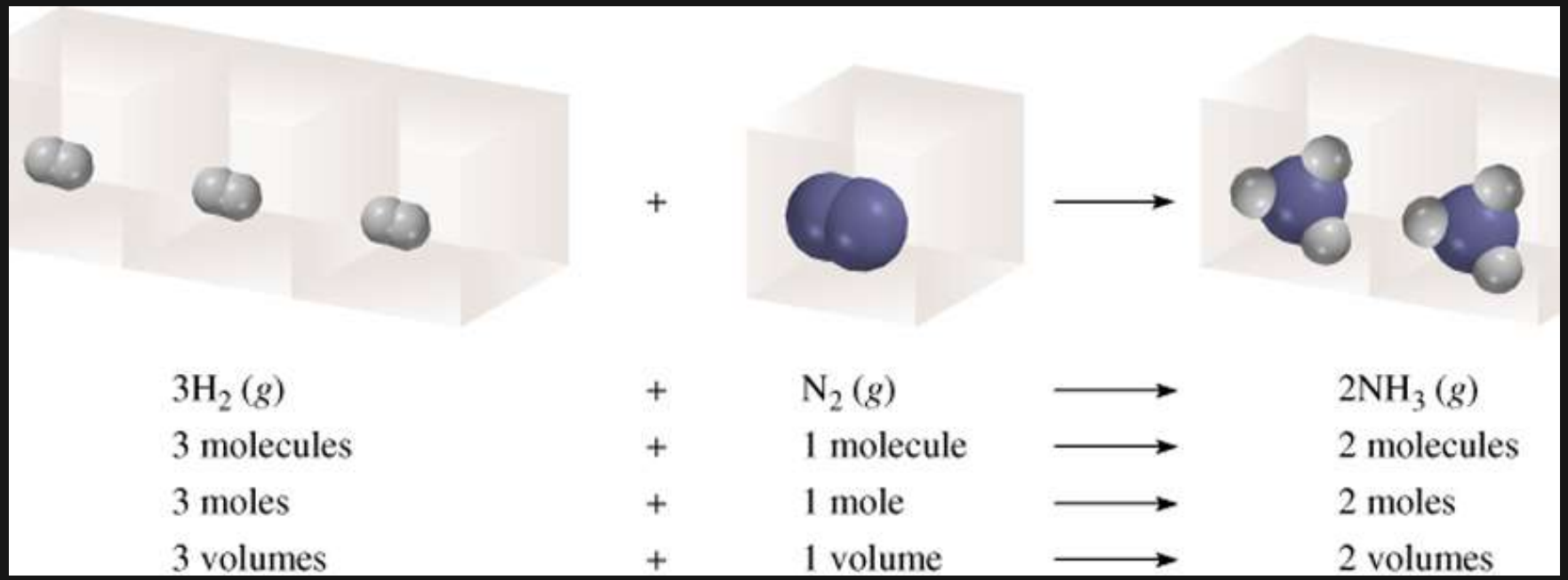
- You will understand the difference between a real gas and an ideal gas
- You will be able to use the ideal gas law to solve calculations involving different quantities of gas particles

Avogadro's Law

At a constant temperature and pressure:

$V \alpha$ number of moles (n)

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$



$3H_2$ (g)	+	N_2 (g)	⟶	$2NH_3$ (g)
3 molecules	+	1 molecule	⟶	2 molecules
3 moles	+	1 mole	⟶	2 moles
3 volumes	+	1 volume	⟶	2 volumes

Try this…

Ammonia burns in oxygen to form nitric oxide (NO) and water vapor. How many volumes of NO are obtained from one volume (mole) of ammonia at the same temperature and pressure?

Ammonia burns in oxygen to form nitric oxide (NO) and water vapor. How many volumes of NO are obtained from one volume of ammonia at the same temperature and pressure?

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

$$1 \text{ mole } NH_3 \longrightarrow 1 \text{ mole NO}$$

At constant *T* and *P*

$$1 \text{ volume } NH_3 \longrightarrow 1 \text{ volume NO}$$

Standard Molar Volume: 1 mol = 22.4 L

At STP an ideal gas occupies a volume of 22.4 L/ mol

So, what volume would 1.25 mole of H_2 gas occupy at STP

Ideal Gas Equation

Boyle's law: $V \propto \frac{1}{P}$ (at const. n and T)

Charles' law: $V \propto T$ (at const. n and P)

Avo's law: $V \propto n$ (at const. P and T)

$$V = \text{constant} \times \frac{nT}{P} = R\,\frac{nT}{P}$$

$$\boxed{PV = nRT}$$

R = 0.082057 L • atm / (mol • K)

What is the volume (in liters) occupied by 49.8 g of HCl at STP?

1. What you want?

2. Given Information

$T = 0\ ^0C = 273\ K$

$P = 1\ atm$

3. Useful formulas/ conversions

$PV = nRT$

$V = \dfrac{nRT}{P}$

4. Plan

Find mols HCl, Solve for V

5. Calculations for solutions

$$n = 49.8\text{g} \times \frac{1\ \text{mol HCl}}{36.45\ \text{g HCl}} = 1.37\ \text{mol}$$

$$V = \frac{1.37\text{mol} \times 0.0821 \frac{\text{L•atm}}{\text{mol•K}} \times 273\ \text{K}}{1\ \text{atm}}$$

$$V = 30.6\ \text{L}$$

Bellwork 02/23/15

1. How many moles of hydrogen gas are produced in the reaction between 0.03g of Magnesium and an excess of hydrochloric acid? (use stoichiometry)

$$Mg + 2HCl \rightarrow MgCl_2 + H_{2(g)}$$

2. Write out the equation for the ideal gas law and label all variables. How is the Ideal Gas Law different from the previous gas laws we have learned?

3. What is the volume of 5.5 moles of CO_2 at STP? How would this value be different at a temperature of 450 K and a pressure of 2 atm?

Agenda

- Collect HW/E.C. Problems
- Review Ideal Gas Law
- Calculating Molar Mass and density using Ideal Gas Law

Objectives

- You will know when to use the ideal gas law and be able to rearrange it to solve for any variable
- You will be able to use the ideal gas law to calculate the molar mass and density of a substance

Test Coming Up!

EQ: What will you do to prepare for the upcoming test? How can you use the results from the previous test to help you prepare better for this one?

A look into the future→

…no school this Thursday and Friday (3 day week)

…test on Thursday, March 5 (no school March 6th)

…**six school days until test day!**

Ideal Gas Law Review

Boyle's law: $V \propto \frac{1}{P}$ (at const. *n* and *T*)

Charles' law: $V \propto T$ (at const. *n* and *P*)

Avo's law: $V \propto n$ (at const. *P* and *T*)

$$V = \text{constant} \times \frac{nT}{P} = R\frac{nT}{P}$$

$$\boxed{PV = nRT}$$

$R = 0.082057\ \text{L} \cdot \text{atm} / (\text{mol} \cdot \text{K})$

Back to the Demo

What was the pressure of the dry gas (P_{H2}) above the liquid once the reaction was complete?

V = 35mL
n = .00125 mol
R = .0821
T = 298 K
P_{total} = ?

$$P = \frac{nRT}{V} = \frac{.00125mol \times .0821 \times 298K}{35\ mL}$$

$$P_{total} = 0.0306$$

$$P_{dry\ gas} = P_{total} - P_{H20}$$

$$= 1\ atm - .0312atm$$

$$= 0.969\ atm$$

Temperature (°C)	Vapor Pressure (mmHg)
0	4.58
5	6.54
10	9.21
15	12.79
20	17.54
25	23.76
30	31.82
35	42.18

More practice

A 0.02 moles of oxygen gas is at 0.5 L at 0.25 atm. At what temperature (ºC) is the gas?

-197 ºC

A 334 mL gas cylinder contains 8.470 g (grams → mol) of helium at 23ºC. What is the pressure (atm) assuming ideal gas behavior?

154 atm

Other uses of the Ideal Gas Law

Density (*d*) Calculations

$$d = \frac{m}{V} = \frac{P\mathcal{M}}{RT}$$

m **= mass of gas in g**

$\mathcal{M}$ **= molar mass of gas**

Molar Mass ($\mathcal{M}$) of a Gaseous Substance

$$\mathcal{M} = \frac{dRT}{P}$$

d = density of the gas in g/L

Try This

Calculate the density of H_2S gas at 0.122 atm and 25.0°C

$$d = \frac{m}{V} = \frac{P\mathcal{M}}{RT}$$

P = 0.122 atm

$\mathcal{M}$ = 34 g/mol

R = 0.0821

T = 298 K

d = 0.17 g/L

Exit Slip

Re-read the objectives for today (below):

1. **On a scale of 1-3 how confident are you that you have learned the objectives for today?**
2. **Why did you give yourself this rating?**
3. **List at least one thing that you feel you need clarification on or need extra practice with.**

You will know when to use the ideal gas law and be able to rearrange it to solve for any variable

You will be able to use the ideal gas law to calculate the molar mass and density of a substance

Bellwork
02/24/15

1. **What is the density of CO_2 at 4 atm and 35 °C?**

2. A bulb with a volume of 225**mL** contains 0.580 g of an unknown gaseous compound. The pressure is measured as 1.44atm at a temperature of 25 °C. What is the molar mass of the compound?

3. **Write out the balanced chemical equation for the combustion of butane gas (C_4H_{10})**

Agenda

- BIC Lighter Lab (calculating molar mass experimentally)

Objectives

- You will be able to determine the molar mass of butane experimentally
- You will be able to calculate % error in your experiment

Before you start collecting data

- **Answer the pre-lab questions and have them checked off by me**
- **Show me that you read the procedure by demonstrating it to me without the lighter**

…after this is complete you will receive your BIC lighter

Bellwork
02/25/15

1. 5g of magnesium reacts with 5g of hydrochloric acid. How many moles of hydrogen gas are produced? (HINT: this is a limiting reagent problem.

$$Mg + 2HCl \rightarrow MgCl_2 + H_{2(g)}$$

2. Using the value calculated from above, determine the volume of hydrogen produced at 760 mmHg and 298K.

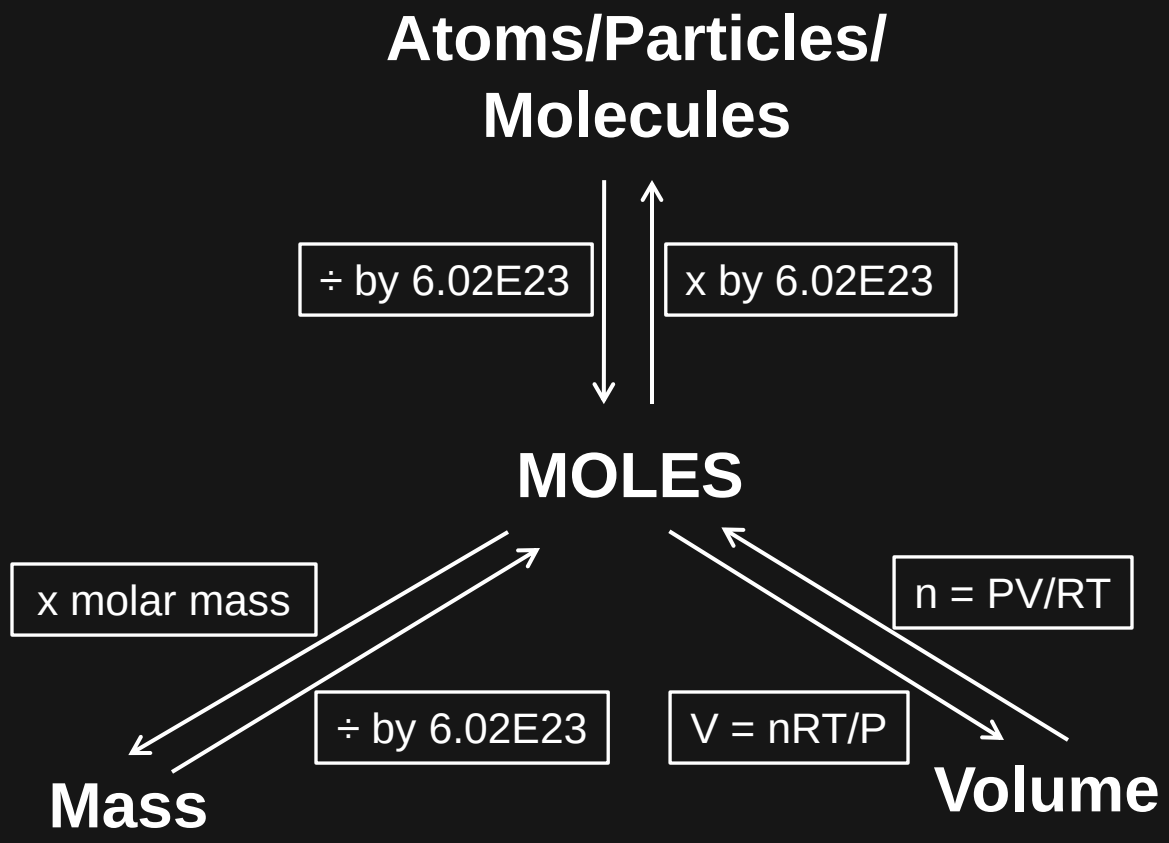
Agenda

- Lab Discussion
- HW questions
- Gas Laws and Stoichiometry

Objectives

- You will be able to determine the volume of a gas produced given the amounts (in grams) of the reactants, the temperature, and the pressure

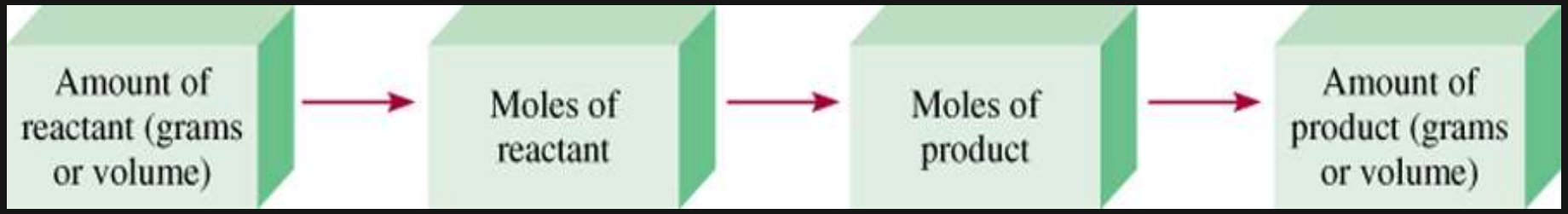
Write this down!



Try This

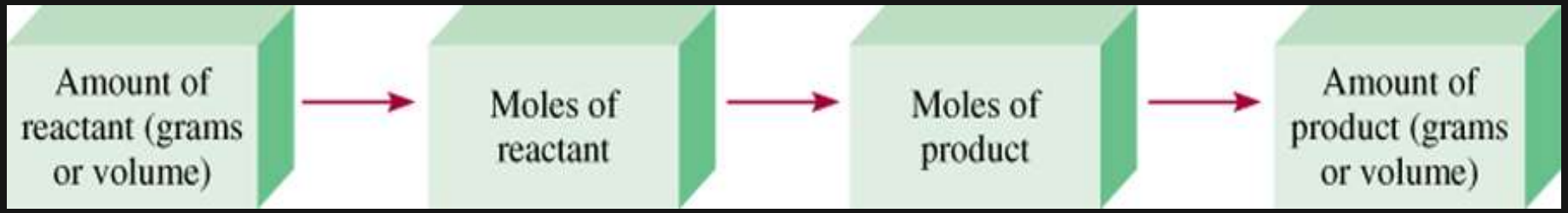
What is the <u>volume</u> of CO_2 produced at 37 ºC and 1.00 atm when 5.60 g of glucose are used up in the rxn:

$$C_6H_{12}O_6(s)+6O_2(g)\rightarrow 6CO_2(g)+6H_2O(l)$$



$C_6H_{12}O_6(s)+6O_2(g) \rightarrow 6CO_2(g)+6H_2O(l)$

1. What you want? V_{CO2}	
2. Given Information T = 37ºC P = 1atm Mass of reactant = 5.6g	4. Plan 5. Calculations for solutions **1.) Calculate how much product can be produced in moles (n)…(gA→molB)** **gA x (1 mol/m.m.A) x (molB/molA)** **2.) Using ideal gas law and the value from step one calculate the volume (L) of the gas at the given conditions.** **V = nRT/P**
3. Useful formulas/ conversions **PV = nRT**	



Try This

$$C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(g)}$$

What volume of water is produced at STP if 7.0 grams of glucose ($C_6H_{12}O_6$) are combusted?

More Practice

$\underline{1}CH_4\,(g) + \underline{2}O_2\,(g) \rightarrow \underline{2}H_2O(l) + \underline{1}CO_2\,(g)$

How many moles of O_2 are used to produce the 3.0L of CO_2 at 400K and 5atm?

Rodeo Break Extra Credit

Read the paper on scuba diving and gas laws and answer the ALL the questions on the worksheet in complete sentences to receive credit.

The paper and questions will be posted online. Let me know if you need hard copies of the material before you leave today.

BELL WORK
03-March-2015

Take a copy of the popcorn lab from the front of the room:

- **Finish summarizing the procedure AND copy down the tables**
- **When finished, call me over to have me stamp it**

I will do a demo of the set-up before we begin

EQ: What is 'GRIT'? What is an example in which you have shown grit in your life?

Agenda

"Pop Corn Lab"

Test Review Handout

Objective

You will KNOW how to use the ideal gas law to solve the water content of popping corn.

POPCORN and PV= nRT

Safety:

Vegetable oil is flammable. Heat the flask with care.

The flask must be securely fastened to the ring stand with a utility clamp.

Do not eat the popcorn!

POPCORN and PV= nRT

You will only be testing 1 of two (2) different brands of popping corns:

Do not weigh any hot or warm flasks!

BELL WORK
04-March-2015

Agenda

Lab Clean-up

Test Review

Clean Up

Period 1:

Period 2:

Period 3:

BELL WORK
03-March-2015

1. **What is the volume of 5.5 moles of hydrogen gas at STP?**
   HINT: 1 mole = 22.4 liters

1. **The pressure in a 2.0 L container of C_4H_{10} is 1.5 x 10^{-4} torr at 1115K. How many moles of C_4H_{10} do you have?**
   HINT: PV=nRT…what units do you need to be in?

1. **What is 'GRIT'? What is an example in which you have shown grit in your life?**